CLAIMS

1. Microlithographic projection exposure apparatus having a projection lens (20; 120) whose last optical surface on the image side is immersed in an immersion liquid (36),

characterized in that

the immersion liquid (36) is enriched with heavy isotopes.

2. Projection exposure apparatus according to Claim 1, characterized in that the proportion of at least one heavy isotope is at least doubled in comparison with the natural isotope distribution.

3. Projection exposure apparatus according to Claim 1 or 2, characterized in that the immersion liquid (36) is enriched with deuterium.

4. Projection exposure apparatus according to Claim 3, characterized in that more than 1 per cent of the molecules contained in the immersion liquid (36) contain deuterium.

5. Projection exposure apparatus according to Claim 4, characterized in that more than 80 per cent of the

molecules contained in the immersion liquid (36) contain deuterium.

6. Projection exposure apparatus according to Claim 5, characterized in that more than 99 per cent of the molecules contained in the immersion liquid (36) contain deuterium.

7. Projection exposure apparatus according to Claim 6, characterized in that more than 99 molar per cent of the immersion liquid (36) consists of heavy water.

8. Projection exposure apparatus according to Claim 7, characterized in that the projection exposure apparatus (10) contains a thermal regulating device (15) by which the immersion liquid (36) can be brought to a set-point temperature, which is at least approximately equal to the temperature at which heavy water has its maximum refractive index for a given ambient pressure.

9. Projection exposure apparatus according to Claim 8, characterized in that the temperature is between about 7°C and about 16°C, and preferably between about 10°C and about 13°C.

10. Projection exposure apparatus according to Claim 8 or 9, characterized in that the projection lens (120) is designed so that the immersion liquid (36) is convexly

curved towards an object plane (22) of the projection lens (120) during immersed operation.

11. Projection exposure apparatus according to Claim 10, characterized in that the immersion liquid (36) is directly adjacent to a concavely curved surface (40) on the image side of the last optical element (L4) on the image side during immersed operation.

12. Projection exposure apparatus according to one of Claims 8 to 11, characterized in that the minimum distance between the last optical surface on the image side and a photosensitive layer to be exposed is more than 2.5 mm, preferably more than 5 mm.

13. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains D_2SO_4.

14. Projection exposure apparatus according to Claim 13, characterized in that more than 10 per cent of the molecules contained in the immersion liquid (36) contain the oxygen isotope ^{18}O.

15. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains D_3PO_4.

16. Projection exposure apparatus according to Claim 13, characterized in that more than 10 per cent of the molecules contained in the immersion liquid (36) contain the oxygen isotope ^{18}O.

17. Projection exposure apparatus according to one of Claims 13 to 16, characterized in that the immersion liquid is an aqueous solution containing D_2O.

18. Projection exposure apparatus according to one of Claims 13 to 17, characterized in that the immersion liquid is an aqueous solution containing HDO.

19. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains at least 1 molar per cent of at least one of the three following perfluoro polyethers:

$$CF_3-[(^{18}O-\underset{\displaystyle CF_3}{\underset{|}{CF}}-CF_2)_m-(^{18}O-CF_2)_n]^{18}O-CF_3$$

with m+n = 8 to 45 and m/n 20 to 1000;

$$CF_3-[(^{18}O-CF_2-CF_2)_m-(^{18}O-CF_2)_n]^{18}O-CF_3$$

with m+n = 40 to 180 and m/n 0.5 to 2;

$$F_2[(CF_2)_3-^{18}O]_n]-CF_2-CF_3.$$

20. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains at least 1 molar per cent of at least one of the two following four heavy perfluoro polyethers:

$DO-CD_2-CF_2O-(CF_2CF_2O)-CF_2-CD_2OD$;

$D^{18}O-CD_2-CF_2{}^{18}O-(CF_2CF_2{}^{18}O)_m-CF_2-CD_2{}^{18}OD$;

$DF_2CO-(CF_2CF_2O)_m-(CF_2O)_nCF_2D$;

$DF_2C^{18}O-(CF_2CF_2{}^{18}O)_m-(CF_2{}^{18}O)_nCF_2D$.

21. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains at least 1 molar per cent of $CF_3(^{18}OCF_2CF_2)_m-(^{18}OCF_2)_n-^{18}OCF_3$.

22. Projection exposure apparatus according to one of Claims 3 to 6, characterized in that the immersion liquid (36) contains long-chained heavy hydrocarbons in which at least 10% of the hydrogen is replaced by deuterium.

23. Projection exposure apparatus according to one of the preceding claims, characterized in that the refractive index of the last surface (32) on the image side is at least approximately the same as the refractive

is at least approximately the same as the refractive index of the immersion liquid (36).

24. Projection exposure apparatus according to Claim 23, characterized in that the ratio of the refractive indices of the immersion liquid (36) and of the surface (32) differs from 1 by no more than 10^{-1}, preferably no more than 10^{-2}.

25. Projection exposure apparatus according to Claim 23 or 24, characterized in that the surface (32) consists of LiF or MgF_2.

26. Projection exposure apparatus according to one of Claims 23 to 25, characterized in that the last surface (32) on the image side is formed by a layer (36) applied by vapour deposition.

27. Projection exposure apparatus according to one of the preceding claims, characterized in that the immersion liquid (36) consists of highly pure water which is supplemented with an accurately established amount of at least one additive that is transparent for the projection light used in the projection exposure apparatus (10).

28. Projection exposure apparatus according to Claim 27, characterized in that the at least one additive dissociates in the immersion liquid (36) so that the electrical conductivity of the immersion liquid is between

about 4 x 10^{-8} S/m and about 4 x 10^{-6} S/m, and particularly preferable between about 3.5 x 10^{-8} S/m and about 6 x 10^{-7} S/m, after adding the additive.

29. Projection exposure apparatus according to one of Claims 27 or 28, characterized in that the highly pure water consists of light water and/or heavy water.

30. Projection exposure apparatus according to one of Claims 27 to 29, characterized in that the at least one additive contains LiF, NaF, CaF_2, SrF_2 or MgF_2.

31. Microlithographic projection exposure apparatus having a projection lens (20; 120) whose last optical surface on the image side is immersed in an immersion liquid (36),

characterized in that

the refractive index of the immersion liquid (36) has a temperature dependency dn/dT which is less than 5 x 10^{-5} 1/K and, in particular, less than 1 x 10^{-5} 1/K.

32. Microlithographic projection exposure apparatus having a projection lens (20; 120) whose last optical surface on the image side is immersed in an immersion liquid (36),

characterized in that

the refractive index of the last surface (32) on the image side is at least approximately the same as the refractive index of the immersion liquid (36).

33. Microlithographic projection exposure apparatus having a projection lens (20; 120) whose last optical surface on the image side is immersed in an immersion liquid (36),

characterized in that

the immersion liquid (36) consists of highly pure water which is supplemented with an accurately established amount of at least one additive that is transparent for the projection light used in the projection exposure apparatus (10).

34. Immersion liquid for a microlithographic projection exposure apparatus,

characterized in that

the immersion liquid (36) is enriched with heavy isotopes.

35. Use of a liquid enriched with heavy isotopes as an immersion liquid (36) in a microlithographic projection exposure apparatus (10).

36. Method for the microlithographic production of a microstructured component, having the following steps:

a) providing a projection lens (20; 120);

b) arranging a reticle (24), which contains structures to be projected, in an object plane (22) of the projection lens (20; 120);

c) introducing an immersion liquid (36) into an intermediate space (34) which remains between a last optical element (L4) on the image side of the projection lens (20; 120) and a photosensitive layer (26), the immersion liquid (36) being enriched with heavy isotopes;

d) projecting the structures onto the photosensitive layer (26).

37. Microstructured component, characterized in that it is produced by the method according to claim 36.